Optimal integration of Maintenance Programs with other safety related programs in a Plant Life Management framework

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ABSTRACT

Due to current social and economical framework, in last years many nuclear power plant owners started a program for the Long Term Operation (LTO)/PLIM (Plant Life Management) of their older nuclear facilities. PLIM/PLEX (Plant Life Extension) has already been implemented in many countries (USA, Russia,etc.). This process has many nuclear safety implications, other than strategic and political ones. The need for tailoring the available safety assessment tools to such applications has become urgent in recent years and triggered many research actions.

The review of regular maintenance and ageing management programs is widely used in LTO/PLIM context in many Countries. However, most of these programmes are rather general and in many cases they need reshaping in an LTO/PLIM framework before application, with focus to the safety implications of the LTO/PLIM. Many Countries and plants radically modified their maintenance rules towards a condition based approach as a precondition for the implementation of LTO/PLIM programs.

Moreover, a PLIM framework requires both a detailed review of the features of the main safety programs (Maintenance, ISI, Surveillance) and a complete integration of these programs into the general management system of the plant. New external factors, such as: large use of subcontractors, need for efficient management of spare parts, request for heavy plant refurbishment programs demand for updated techniques in the overall management of the plant. Therefore new organisational models have to be developed to appropriately support the PLIM framework, integrating both safety related and non safety related issues.

In 2004 a network of European Organisations operating Nuclear Power Plants, SENUF, under the coordination of the JRC-IE, carried out an extensive questionnaire on maintenance practice in their facilities aiming at capturing the aspects of the maintenance programs where research is mostly needed. This paper uses some results of the questionnaire, which was not oriented to LTO/PLIM, to draw some conclusions on how the current maintenance programs could support a potential LTO/PLIM, among the other programs running at NPPs. A joint IAEA-JRC workshop in 2006 confirmed the conclusions of the questionnaire and added new issues to the picture.

The paper aims at identifying the technical attributes of the maintenance programs more directly affecting the decision for a long-term safe operation of a nuclear facility, the issues related to their implementation and the most suitable organisational framework for a proper implementation.

1 INTRODUCTION

The SENUF (Safety of European Nuclear Facilities) network was established in 2003 to facilitate the harmonization of safety cultures between the Candidate Countries (CCs) and the European Union (EU), the understanding of needs to improve the nuclear safety in CCs, and the dissemination of JRC-IE nuclear safety institutional activities to CCs.

The SENUF agreement [1] was signed on September 1, 2003. The Working Group on "Safety of Nuclear Facilities in Eastern Europe dedicated to Nuclear Power Plant Maintenance" was founded with the following objectives:

a) Review and identification of the remaining open (generic/specific) maintenance related issues,
b) Promotion of well designed and prepared maintenance plans for systems, structures and components,
c) Support for the implementation of advanced maintenance approaches, including implementation of preventive (condition based) maintenance as well as preventive mitigation measures,
d) Evaluation of the advanced risk based maintenance approach and provision of assistance in its implementation.

The following Countries, through national electrical Utilities or NPPs joined the network: Endesa Genercion, Paks NPP, Framatome ANP, Krsko NPP, Bohunice NPP, Ignalina NPP, Tractebel Engineering, Temelin NPP, Energoatom Ukraine. In the period between the first and second Steering Committee meeting also the Bulgarian NPP Kozloduy joined the network.

Since 2003, the SENUF network issued 7 monographic documents, organised 6 international workshops and specialist meetings, and developed a database on special maintenance issues [2,15-18]. The reports collected and evaluated the available and applied maintenance methods at NPPs of acceding and candidate countries to the European Union (ACCs) as well as of the wider Europe (covering Russian Federation and Ukraine), and based on this evaluation, preliminary identified areas for further collaboration with them.

After 4 years of successful operations, the SENUF network was integrated into the new Direct Action of the European Commission, SONIS (Safe Operation of Nuclear Installations), where research on maintenance optimisation

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plays a major role. At the same time the network was enlarged to all potential SONIS stakeholders, such as Senior Representatives of Organisations operating in the field of Operational Safety and Maintenance Optimisation in particular, in order to collect the most updated feedback from the research and plant operating experience for an optimal planning of the SENUF activities inside SONIS.

The objectives of this paper, spin-off of the above mentioned activities, are the following:

- To identify differences and commonalities in European practice, and based on this evaluation, to identify areas for further research and development (R&D).
- To analyze and summarize the existing strategies on nuclear power plant (NPP) maintenance optimization, i.e. predictive maintenance based on monitoring component condition, reliability centred maintenance, and risk-informed maintenance in the NPPs of the collaborating parties
- To identify the technical attributes of the maintenance programs more directly affecting the decision for a long-term safe operation of a nuclear facility, their implementation issues and safety review.

2 THE OUTCOME OF THE SENUF RECENT INITIATIVES ON MAINTENANCE OPTIMISATION

2.1 General

An international workshop (WS), cosponsored by the International Atomic Energy Agency (IAEA) and the Institute for Energy (IE), held in 2006 in Petten [18] highlighted the following generic needs of the participants (with some differences according to the country framework):

1) Need to control the maintenance cost, particularly in liberalized energy markets, through reduction of unnecessary tasks and optimized maintenance periodicity
2) Improvement of plant safety through better scheduling of maintenance activities
3) Optimization of the management organization, more suitable to control plant safety
4) Development of pre-conditions for the plant life extension
5) Support the production through minimization of outages duration and optimized work control, not challenging safety
6) Minimization of the radiation doses
7) Optimized integration among existing safety programs, such as: ISI, AMP, configuration management, design basis reconstruction, etc.

In relation to the operating cost reduction as a consequence of the application of optimised maintenance programs such as the RCM (Reliability Centered Maintenance), the participants highlighted the following reductions:

- In Sweden, 10 - 20% of the effort, especially for I&C calibration intervals
- In Spain, 20% in work, 30% in number of tasks
- In Hungary, expected, not quantified
- In Czech Republic, 30% on a restricted number of systems selected for a benchmark (according to the implemented Phare project in Dukovany NPP)
- In Slovakia, expected, not quantified.

Despite of that, a generic reluctance was recorded in some Countries by the Regulatory Body in the adaptive modification of the maintenances policy on the basis of component reliability studies.

2.2 Main technical features of the RCM programs

In relation to the “scoping” process applied in the maintenance approaches based on the analysis of the degradation and the potential adaptivity of the inspection and maintenance tasks (such as condition-based-maintenance (CBM) or reliability-centred-maintenance (RCM)), it was noted that the approaches are quite different in the Countries:

- In Sweden RCM is applied only to non-safety related SSCs. Safety SSCs are analyzed only to get a documented base for the preventive maintenance (PM) program. Analyzes of safety system seldom result in any changes of the existing PM-program. The process to get a change of the Technical Specification requirement are very strict and in most cases not worth the effort.
- In Hungary RCM is applied to 70% of the safety related SSCs and to 30% of other systems
- In Slovakia RCM is applied to 44 systems (100-500 components) selected on the basis of different criteria, including safety significance.

The quality of the maintenance documentation was recognized as crucial to feed a proper feedback mechanism. The culture of communication (including the “no blame”) may play a major role in ensuring all failure mechanisms have been properly identified and all actual equipment failures have been recorded.

It was also noted that in the current dynamic industry an optimized maintenance system should be adaptive. In particular mechanisms should be put in place to deal with configuration changes, changes of suppliers, emerging results from the aging management programmes (AMP), etc. The need for implementation of a living RCM program under the responsibility of the system engineer was highlighted.

Performance Indicators for maintenance effectiveness are considered very useful and welcome, however it was recognized that some research work is still needed in this field. It was felt important for the International organization to provide assistance in this field and set up some benchmarking studies.

The WS identified a number of issues in the field of the component integrity and reliability of SSCs. It was recognized that data banks are available with failure data at the plant level (SP), at the utility level (SWE, FI), but they are mainly used for PSA input. The consequences of a failure are often evaluated with POA (Probabilistic Operational Assessment): however, these tools are usually expensive and therefore their use is limited to very exceptional cases. The equipment reliability to be used in the RCM is still evaluated in most cases by expert judgments and by analysis of the feedback experience.

However, the availability of time records for component performance is crucial: in Spain three years of historical data fed the statistical analysis, complemented by the PSA. The digital I&C cannot be easily predicted in time, even if a monitoring system is available, as the failure mode is difficult to be defined; therefore the failure rate usually is provided by the supplier who can derive it on the basis of the whole population of the installed equipment. More in general, there is no shared data base on maintenance among NPPs. Some data bases are available on component reliability: the experience of DACNE for PSA failure probabilities and for maintenance rule performance criteria (by Tecnatom), the EPIX (by INPO) and the PKMJ (by EPRI). However, most of them remain country specific and/or restricted to the contributing users. Neither non-nuclear plants are involved in this exchange of experience. Some maintenance forum (such as EPRI/NMAC) provides a certain level of experience exchange, however again restricted to members.

At all plants the interfaces between ISI databases and MR databases are still poor, due to their history: ISI data bases are mainly related to passive components, “maintenance rules” (MR) , in the sense defined by EPRI, to the active ones.

At last, the exchange of experience with the non-nuclear industry, particularly the aerospace, proved very beneficial in some countries (HUN, SLR); this practice should be extensively applied.

2.3 Organisational issues in relation to maintenance optimisation

All available sources of information highlighted that the implementation of the optimised maintenance systems poses major challenges to the organization: in some cases the interfaces among existing departments were so many that new structures had to be developed. In other cases (Spain) the organization did not change and only the coordination was improved. Also in the US, the objective of the action was the re-definition of the interfaces. The interfaces are very sensitive to the changes in plant configuration and should be promptly updated in such cases.

The implementation of optimized maintenance programs should include specialized training to many involved people. Two levels of training are needed: a specialized one to the directly affected people (6 months, retrained every 3 years) and a more generic on the objectives to the staff at large. RCM-Methodology Training for the project team before starting the case study or pilot project is essential for a successful project. To get maintenance management to promote and accept an RCM-project they also need some training before the project starts.

To this concern, the importance of the availability of state-of-the-art training centers, maintenance manuals and procedures was highlighted. In some cases (HUN) the training of the contractor’s personnel is controlled by the plant, in other cases (SWE) it is audited. The Country tradition and labor market suggest to develop tailored solutions. Training is also carried out on-the-job, through continuous exchange of experience and periodic meetings of the steering project team.

More in detail, the following difficulties and challenges were identified during the RCM implementation in the Countries participating at the network tasks:

1) The regulatory body acceptance of the changes in the maintenance program as a result of component reliability analysis may play a crucial role, in particular in the analysis of the interfaces wit the Technical Specifications (TS) of the plant
2) The RCM increases the amount of paper work: if it is not well driven, it may represent a useless burden on the operators. Therefore, the massive use of computer systems becomes almost unavoidable
3) The RCM requires an optimized management of the interfaces between departments and safety programs: a bad coordination may prevent a successful implementation of the RCM
4) There are objective difficulties in the implementation of the RCM due to the required change in mentality of the personnel and amount of extra work in some cases (particularly when the RCM is not fully computer assisted)
5) The quality of the maintenance record sheets is crucial to feed the system with a proper feedback

The main steps of the establishment of the RCM at the site were identified as in the following: component classification and scoping, goal setting, definition of the steering group, definition of the case studies, training of personnel, benchmarking the foreign experience, procedure development, appropriate software development or adaptation, interfaces with the management system of the plant (for spare parts, work order, etc.), definition of the peer review mechanisms.

In relation to the Project management for a maintenance optimization project, a steering group is the most common startegy, which should be settled at the beginning for the project startup (lasting usually for 3 years). The implementation of an RCM program should start from a special project team, with a limited number of people, dealing with a selected limited set of sample systems (4-6 people can manage up to 200-300 components). After that, the RCM should be incorporated into the maintenance department. In most of the plants that have introduced RCM successfully this latter step proved to be easy. In the RCM, the system engineers play a crucial role is the assessment of system reliability and operational requirements, as well as in the management of all the interfaces with ISIS, AMP, configuration, etc.

2.4 The future of the RCM programs

The workshop identified two areas where some effort is needed to support the full implementation of RCM models in European Countries. These areas cover research tasks and call for an initiative at the International Organizations level.

In the field of regulatory practice, support would be needed in the involvement of the Regulator in the advanced maintenance optimization applications and information on the regulation in the countries with good practices in the field. In particular, the following recommendations for future support from international organizations were identified:

- Develop detailed guidelines for regulatory review of specific maintenance optimization applications such as: RI TS, RI ISI, On-line maintenance, etc.
- Provide training and/or training material, tutorials for regulatory review of maintenance optimization applications.
- Promote benchmark exercises.
- Expand the scope of the IAEA safety review missions to specific maintenance optimization applications.

In terms of research tasks able to make the RCM more broadly applied, the following was identified:

- Clarification of the reliability target for the different groups of components and reliability parameters calculation
- Integrated management of the data bases available at the plants: many sources of data are available at the plants (ISI, maintenance, AMP, PSA, operation, etc.) but often they are not integrated and they do not support an integrated approach to component reliability.
- Development of criteria for “good” performance of SSCs (acceptance criteria)
- Identification of representative maintenance effectiveness indicators
- Understanding of the impact of the RCM on the workforce: in relation to different competencies needed and overall reduction of the workforce at the sites
- Comparison of the available methodologies for RCM: the available proposals are very much affected by the national frameworks where they have been developed. Benchmarking on selected systems and commodity groups would be very useful to this concern
- Exchange of information at the EU and international level in general, despite of the national differences and plant issues, would be very useful in the following areas:
    - Methodologies for RCM
    - Organizational aspects
    - Failure rates for commodity groups (with some assumptions on anchoring, environment, etc.)
    - Training of personnel and use of training centers

2.5 Analysis of statistics and questionnaires

Recent statistics carried out in the USA (INPO) show that 40% of the failures are related to human factors: among them, 30% are related to engineering deficiencies an 30% to work performance. Most of the significant events in the latter category have been triggered by the supplemental workers. Therefore the contractor performance becomes a crucial issue where many utilities are investing large effort for their reduction. Also supplier reliability is an issue: in many cases equipment were delivered with wrong or different specifications.

Performance indicators are becoming an essential tool for maintenance optimisation, as based upon: ownership, time from exceedance of the performance criteria and setting of new goals, number of returns to list of items which require special monitoring of the degradation, site awareness, use of MR to drive performance, etc. Many Countries use the availability and reliability concepts defined in the MR also to monitor the effectiveness of the ageing management programs (AMP).

A special group of indicators is under development at INPO [3], on the “supplemental workers” and the “supplier reliability” in general. They are recognized as very useful to monitor one of the main causes of deficiencies in the maintenance systems (they are included for example in the AP-930)

Eleven Organisations participated to the survey on maintenance practice through the questionnaire jointly prepared by the JRC/IE and the IAEA in 2006. The most relevant conclusions are collected in the following:

- Almost all countries are implementing projects on maintenance optimisation, though with different approaches and scope. Extensive maintenance optimization projects are ongoing in BUL, ROM, SLR, SP, SWE, GER;
- RCM is formally implemented in SP, SWE, SLR, while LIT is concentrated on ISI and GER on outage optimisation.
- Few countries have specific regulatory requirements in the field of maintenance optimisation: SP and US apply the Maintenance Rule; Slovakia is developing regulatory documents on integrated maintenance approaches.
- No data are provided in relation to costs of maintenance optimisation programs; only Spain presented data in relation to the implementation of the RCM.

- LIT provided specific details on benefits from RI-ISI; GER on the outage optimisation, and SP on qualitative insights. However, no quantitative evaluation of the benefits coming from the maintenance optimisation were provided.
- Almost all Countries have computerized in-house system to record component failures and maintenance events.
- Not sufficient information was provided on PSA quality and requirements on PSA models used for RCM justification.
- Quantitative criteria in the PSA application to maintenance are applied by BUL and LIT; qualitative in GER and SP.

In conclusion, the questionnaire provided a first insight in the Country practice in relation to maintenance optimisation and in particular in application of RCM methodologies. In general, it can be concluded that for most of Central and East Europe countries these programs are still at the beginning and more analysis is needed to capture the differences in the Country approaches and to promote harmonization and application of best practices. Dissemination of the lessons learnt from the maintenance optimization in experienced countries like Spain and Sweden can further facilitate this process.

3 THE MAINTENANCE PROGRAM IN THE LONG TERM OPERATION PERSPECTIVE

General

The Long Term Operation (LTO) Programme at NPPs mainly addresses the assessment of the degradation of components and structures and therefore affects the ageing management program. However, there is a generic convincement in the nuclear community, also confirmed by the SENUF questionnaire results, that also the maintenance program should have specific attributes in order to support a long term operation (LTO/PLEX) program for the plant. In this sense, the International Standards (e.g. the IAEA [4,5]) can be seen, but also the national experience of USA, Spain, Hungary, etc. More specifically, the maintenance programs based on standard preventive maintenance (time based), not oriented to the monitoring of its effectiveness, are not considered suitable to support the LTO/PLEX programs. Crucial attributes for maintenance programs in order to support LTO/PLEX are considered: the verification of the performance goals, the root cause analysis of failures, the feedback from maintenance to the ISI program, and the feedback on the OLC (operational limits and conditions).

All Countries implementing an LTO/PLEX program applied extensive modifications to their requirements on maintenance at first step, setting up mechanisms to monitor the effectiveness of the maintenance activities. In particular, the following features are believed to be indispensable for a maintenance program:

1. Monitor the performance of the SSCs (structures, systems and components) which may have impact on safety during all operational statuses of the plants;
2. Assess and manage the risk that may result from the proposed maintenance activities in terms of planning, prioritisation, and scheduling.

In order to implement these requirements, some issues have to be addressed, namely:

1. The identification of the **scope** of the condition based maintenance rules: typically the Countries choose the safety related SSCs, SSCs which mitigates accidents or transients, SSCs interacting with safety related SSCs, and SSCs that could cause scram or actuation of safety related systems. Therefore, many non-safety related SSCs may see the application of such maintenance rules, with augmented efforts in monitoring their performance and planning their reparation.
2. The setting of the performance **goals** for every component in the scope of the maintenance rules, ranking them according to their risk significance for the plant safety. This task may end up very challenging as, when industry experience is not available, either dedicated PSA tasks have to be developed (with special requirements on PSA quality) or special qualification programs for the evaluation of the component reliability.
3. The performance **monitoring** techniques for the very broad categories of structures systems and components in the scope of the rules.
4. The assessment of the safety **during implementation** of maintenance actions.
5. The **feedback** from the result of the monitoring of the component reliability back into the inspection, surveillance and maintenance procedures. Root cause analysis, equipment performance trend analysis and corrective actions have to be developed on a case by case basis.

In this sense the experience of the USA and Spain (where a LTO/PLEX program is well established), Hungary, and Finland (where a PLIM model is in place at the Loviisa NPP) are a confirmation of this generic statement: all these countries modified their regulatory requirements or practice on maintenance, in the direction mentioned above, as one of the preconditions for the LTO/PLEX of their plants.

The SENUF WG carried out a supplement of analysis on the experience of some of the above mentioned countries on the interfaces between LTO/PLEX and maintenance programs, as a background for the development of a state-of-art approach to modern maintenance programs.

Experience at the IAEA in the review of LTO/PLEX and maintenance programs

The IAEA has not yet developed specific documents on the detailed procedure to be followed for the extension of the operational lifetime, as the approach in the countries is very differentiated and in many cases not yet mature. However, a large number of IAEA documents are available on basic safety concepts that could be relevant to life extension programs, and in particular on the requirements of the maintenance programs in view of LTO/PLEX programs [6-10]. A clear position is common to all the IAEA documents:

- LTO/PLEX is a program that can be implemented only when the plant can demonstrate that it will maintain a suitable safety level in all its statuses
- The LTO/PLEX program are crucially based upon a strong integration of many existing programs at the plants, such as ageing management, configuration control, predictive maintenance, etc.

The Regulatory frameworks for long-term operation (LTO/PLEX) differ from country to country in accordance with the licensing system. However, despite of the differences that affect the regulatory strategy in the countries and the consequent differences in the application/approval process for LTO/PLEX, the main technical components of the LTO/PLEX programs and their basic technical tasks are shared among most of the countries.

A general approach to LTO/PLEX, independent of the regulatory framework, can be based upon the following assumptions [13]:

1. Separation of "pre-conditions to LTO/PLEX" and "LTO/PLEX specific" tasks;
2. Separation between regulatory issues (life extension, periodic safety review, plant life management, etc.), technological issues (degradation) and economical issues;
3. Clarification of the LTO/PLEX scope and objectives, and therefore of the interfaces between maintenance, ISI (in service inspection), AMP (ageing management program), etc.;
4. Analysis of the differences between active and passive SSCs, replaceable and non-replaceable components.

This approach leads to the following definitions:

1. **Preconditions for LTO/PLEX**: tasks needed to reach the required level of plant safety and to prove it. Required also for current operation during design life (see for example the safety factors of the periodic safety review). They may include the following actions/programs:
    - Keeping the SAR (safety analysis report) updated, and more in detail:
        - Keeping the EQ (equipment qualification) updated;
        - Keeping the design basis updated;
        - Update the EE (external events) hazard;
        - Update the accident analysis;
    - Existing NPP programmes necessary to support LTO/PLEX, including a**ppropriate maintenance program, with monitoring of its effectiveness and trending features in time**
2. **LTO/PLEX specific tasks**: tasks needed to maintain the required level of plant safety in the long term in relation to material ageing, technological obsolescence and staff knowledge, beyond the plant life defined at the design phase by the technological limits. They are affected by the extension of the beyond design basis lifetime. They may include the following actions/programs:
    - Trend analysis of material and component degradation;
    - Management of the staff ageing;
    - Management of the long term technological obsolescence of SSCs
    - Public acceptance;
    - Environmental issues (population, installations, emergency planning);

The application of this framework leads to an LTO/PLEX process, as shown in Fig.1 [13].

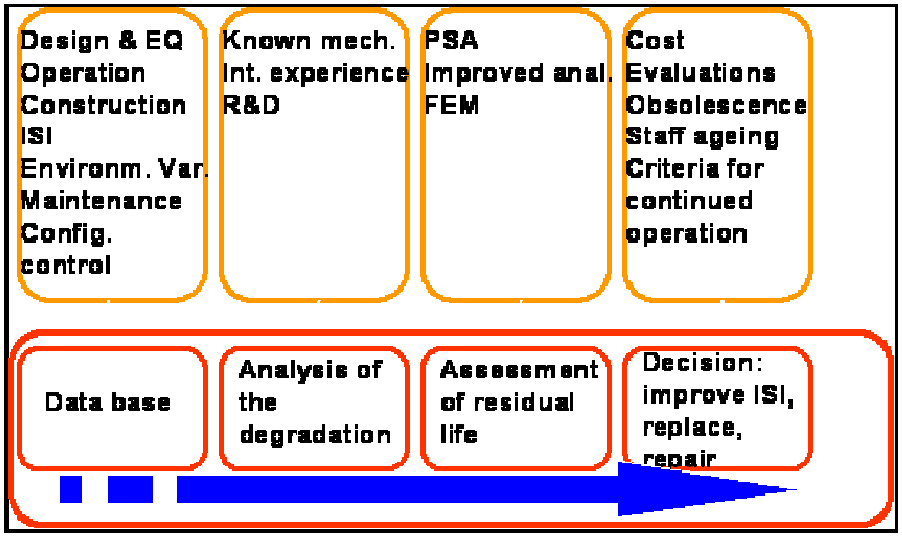

Figure 1 – Reference LTO process

Therefore, an essential element of the LTO/PLEX programme is the extrapolation of the detected degradation on the planned operational lifespan. The licensee should demonstrate that for the extended operational lifetime [11-14]:

1) The safety and ageing analysis remain valid and could be projected to the end of intended operational lifetime;
2) The effects of ageing on the intended function(s) will be adequately managed;
3) There is a mechanism to deal with unexpected ageing mechanisms that can surface.

In general, ageing is addressed in procedures for maintenance, surveillance, in service inspection program, etc. as one of the physical processes, which could lead to failure. The operating experience shows that active and short-lived SSC are in general addressed by existing maintenance programs. Conversely, the performance and safety margins of the passive long-lived SSC are assumed to be guaranteed by design. However, the analysis of the operating experience showed that unforeseen ageing phenomena may occur either because of shortcomings in design, manufacturing or by operating errors. Therefore the implementation of an AMP and a predictive MS&I (maintenance, surveillance and inspection) program is definitely a condition for the operation within the limits of design or licensed lifetime and is a pre-condition for an LTO/PLEX as well.

In conclusion, both the AMP and MS&I programs are considered appropriate if the following actions are completed:

- Program scope is defined;
- Preventive actions are developed;
- Parameters to be monitored or inspected are detected;
- Detection of ageing effects is ensured;
- Monitoring and trending is performed;
- Acceptance criteria are defined;
- Corrective actions confirmation process are defined;
- Administrative control is fixed; and
- Operating experience feedback of the programme is considered.

Some of these attributes are inter-related. Particularly the frequency, the trending and the number of locations to be monitored may reflect the operating experience from past operation.

4 CONCLUSIONS

The analysis of the experience described in the previous chapters suggests that improved maintenance programs could effectively meet the challenges posed by the new socio-economical framework where the nuclear plants have to operate: market liberalization and long term operation of the plants, respectively.

All Countries facing the above mentioned scenarios are spending their best efforts in the improvement of the maintenance programs in the following areas: a) human factors, b) condition based programs and c) trend analysis of degradation mechanisms in the long term, which could definitely support the evolution of the actual maintenance programs in the direction required by the new challenges.

These areas deserve additional R&D in order to reach the full applicability to real cases.

In fact, in the specific case of the SENUF Countries, all members shared the theoretical conclusions of the need to optimize the maintenance programs in the mentioned directions. However, many practical issues still have to be solved before a broad application of the proposed techniques is completed, particularly at some VVER plants, as stated for example in many IAEA documents.

The above mentioned issues suggest that an extra effort is needed by the engineering community to make the predictive maintenance approach fully applicable to all European installations. The effort should comprise R&D on material degradation mechanisms and applicability of probabilistic tools, but also organizational issues and human factors. This effort may be used in a LTO/PLEX perspective, but not necessarily. An improved maintenance system, as highlighted by the SENUF questionnaire, represents a significant improvement in the control of the plant life and its safety, even before the end of its design life.

In fact in the questionnaires many plants claim the broad application of ageing control, control of the modifications and other apparently isolated programs. There is the feeling that the improvement of the maintenance rules should also represent the chance for a better integration of many existing programs, currently run by different departments and with not much interaction under the objective of the overall plant safety.

In conclusion, the next effort of the SENUF initiative may be spent at two different levels, in the improvement of the maintenance systems, with or without an LTO/PLEX perspective:

1. At the **organizational level**, covering the integration among existing programs, management of human factors, definition of feedback loops and interactions between programs, decision making process (either risk informed or not).
   One model that seems to cover these aspects is, for example, the Life Management Programme (PLIM) which aims at keeping the plant in good condition in the long-term, usually with a time target of 50-60 years. This includes careful operation and maintenance, development of a replacement strategy (particularly when lack of spare parts is a reality), and mitigation of ageing effects. This kind of PLIM program needs continuous and effective links from the operating experience to the long-term decision-making. A regulatory tool for assessing and approving the long-term operability might be either the licence renewal or the PSR. However, the use of the PLIM to ensure the LTO/PLEX can be misunderstood: the scope of the PLIM may not cover all ageing relevant issues up to the end of the extended lifetime of the plant. The advantage of a mixed system PLIM + PSR is that the identification and the resolution of the safety issues are not only completed in the frame of the PSR, but it is continuously addressed during the operation.
2. At the **technical level**, improving the applicability of existing pioneering techniques to other existing plants, especially VVERs, where many practical issues appear to provide even additional challenges on their implementation. It is the case of the investigation of ageing and degradation mechanisms for VVER components, of the simplified use of probabilistic tools for condition based maintenance and risk informed inspections, of the use of reliability concepts for performance goal setting and monitoring, and of their trending in time.
   Two sub-actions may be taken at this level: 1) develop a data base on degradation mechanism for VVER components and relevant monitoring techniques in all environmental conditions (including harsh and "standard"), and 2) development of suitable risk based techniques for the safety assessment (also when adequate PSA studies are not available at the plant) of the reliability evaluation of systems and components (performance goal settings, monitoring and trending), optimization of inspection techniques and assessment of the risk associated to the maintenance actions.

This additional R&D, also triggered by countries with urgent LTO/PLEX programs, will be extremely beneficial to operating plants, in the improved control of their safety and operational costs.

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